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(54) Abstract Title
Pneumatic tyre with circumferential and angled tread grooves

(57) Six block rows extending in a tire circumference direction are formed by a central narrow groove 2, side main grooves 3,4, and left and right lug grooves 5 in a tread surface, the rotating direction R of which is specified to one direction. The average tire circumference direction length of the blocks of the block rows in the center area of the tread surface is 4 to 5 % of the tire full circumference length on the tire center line. Each of the left and right lug grooves 5 is formed as a tapered groove having wider groove width at the tire center line. Left and right main groove portions 3a,4a located between the lug grooves are formed as inclined grooves inclining so as to expand towards the reverse direction to the rotating direction of the tire. Subgrooves 7 crossing the blocks in the tire width direction are formed on the surfaces of the blocks in the shoulder areas.

Fig. 1

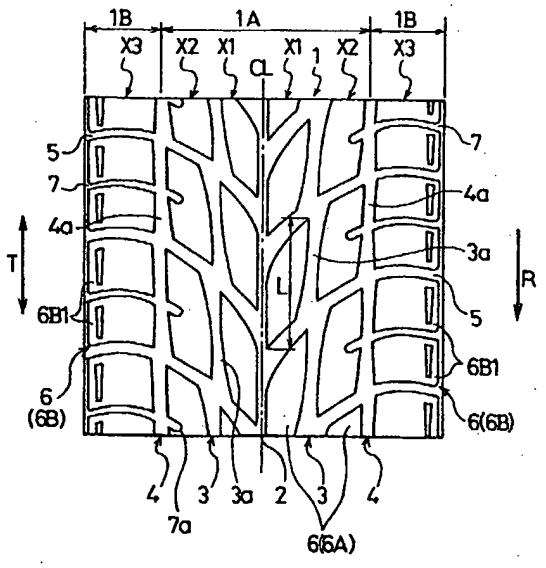

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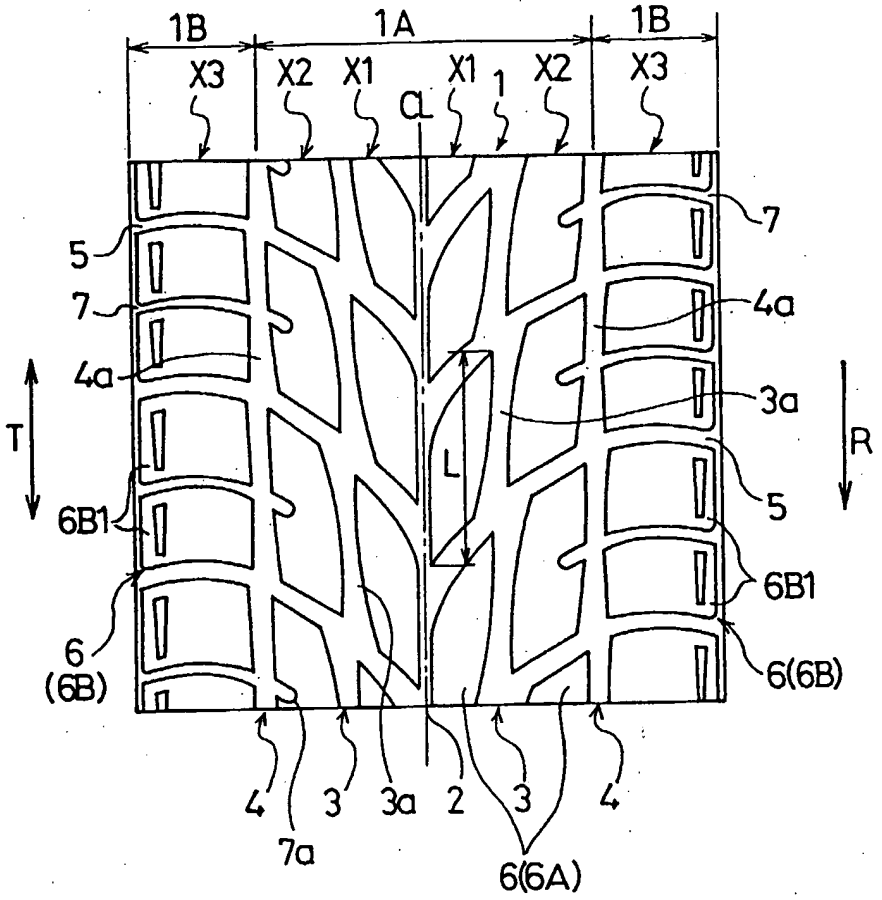
Fig. 1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PNEUMATIC TIRE

BACKGROUND OF THE INVENTION

The present invention relates to a pneumatic tire and, more specifically, to a pneumatic tire capable of improving dry performance (running performance on a dry road) and wet performance (running performance on a wet road), while maintaining noise performance and uneven wear resistance.

In a pneumatic tire having a block pattern which comprises a large number of blocks, defined by straight main grooves extending in a circumference direction of the tire and lug grooves extending in a width direction of the tire on the tread surface, it is very difficult to make the wet performance and the noise performance compatible. That is, it is necessary to widen groove width to improve the wet performance. As a result, the noise performance is degraded due to increase in the groove area. On the other hand, in order to improve the noise performance, it is needed to narrow the groove width. As a result, drainage effect is degraded owing to decrease in the groove area, thereby causing degradation of the wet performance. Therefore, in a pneumatic tire having a conventional block pattern, the wet performance and the noise performance are in an antinomic relation that when one is improved, the other is degraded, and when the other is improved, one is degraded.

To solve the problem mentioned above, there is proposed a technique that V-shaped grooves are placed on the tread surface at a predetermined pitch in a circumference direction of the tire, instead of placing the foregoing main grooves. This can reduce air column resonance in the grooves while securing good drainage effect, thereby lowering noise around 1kHz. However, on the other hand, there is a problem that the uneven wear resistance of the blocks defined by the V-shaped grooves is degraded.

SUMMARY OF THE INVENTION

An object of the present invention is to provide a pneumatic tire capable of improving wet performance and dry performance while maintaining noise performance and uneven wear resistance at a level equal to the prior art or higher.

To achieve the above object, a pneumatic tire according to the present invention includes a tread surface the tire rotating direction of which is specified to one direction. A narrow groove extends straight in a circumference direction of the tire on a tire center line of the tread surface. Two main grooves extend in the tire circumference direction on each of left and right sides of the tread surface. Left and right lug grooves are provided on the tread surface at a predetermined pitch in the tire circumference direction, the lug grooves inclining to the reverse direction of the tire rotating direction and extending from the narrow groove

towards both outsides in the tire width direction. Four block rows in a center area of the tread surface and one row in each of left and right shoulder areas are defined by the narrow groove, the main grooves and the lug grooves, the block rows extending in the tire circumference direction.

The average tire circumference direction length of the blocks of the block rows in the center area is 4 to 5 % of the tire full circumference length on the tire center line. Each of the left and right lug grooves is formed as a tapered groove having wider width on the side of the tire center line and narrower width on the side of the shoulder area. The left and right main grooves have main groove portions located between the lug grooves arranged at the predetermined pitch in the tire circumference direction. The main grooves portions are formed as inclined grooves inclining so as to expand towards the reverse direction to the tire rotation direction. The main grooves are formed by continuously connecting the inclined grooves so that when the tread surface is developed for one round of the tire in the tire circumference direction and when the main grooves are viewed from the tire circumference direction, an unobstructed view can be obtained between one circumference end and the other circumference end of the main grooves. A subgroove is provided on a surface of each block in the left and right shoulder areas, the subgroove crossing the block in the tire width direction.

As mentioned above, since the average tire circumference direction length of the blocks in the center area of the tread surface is 4 to 5 % of the tire full circumference length and the block length is larger than that of conventional ones, stiffness of the blocks in the center area can be increased. Therefore, the dry performance can be improved.

Since lug grooves are formed as inclined grooves inclining to the reverse direction to the tire rotating direction and the width of the lug grooves is wider in the center area which largely affects drainage ability, wet performance can be improved in comparison with conventional tires having the same groove area.

Noise is increased by making the average tire circumference direction length of the blocks longer in the center area of the tread surface while making the groove area of the lug grooves larger as mentioned above. However, air column resonance by the main grooves is reduced, since the left and right main groove portions defined by the left and right lug grooves are formed as inclined grooves, whereby noise around 1 kHz can be lowered.

In the shoulder areas, since the blocks are divided into small blocks by the subgrooves, a number of pitch in the shoulder areas defined by the subgrooves and the lug grooves is substantially two times of that in the center area. Thus, the number of pitch is different in the center and shoulder areas,

which contributes to conversion of pitch noise to white noise.

Since the groove width of the left and right lug grooves is gradually narrower towards outsides of the width direction of the tire, air pumping noise caused by the left and right lug grooves can be reduced in the shoulder areas.

Therefore, noise increase caused by improvements in the dry performance and the wet performance is offset and the noise performance can be maintained at an equivalent level to conventional tires.

Since the narrow groove and the main grooves formed in the tread surface extend substantially straight along the tire circumference direction as in the prior art, uneven wear resistance may not be degraded unlike a tire having V-shaped grooves.

BRIEF DESCRIPTION OF DRAWING

FIG. 1 is a developed view showing a principal portion of the tread surface of a pneumatic tire according to the present invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENT

Shown in FIG. 1, a pneumatic tire according to the present invention includes a tread surface 1, the tire rotating direction of which is specified to one direction shown by arrow R. One narrow groove 2 extending straight in a circumference

direction T of the tire is provided on the tire center line CL of the tread surface 1. On the tread surface 1 located on both sides of the narrow groove 2 in a tire width direction, two left and right main grooves 3 and two left and right main grooves 4 extending in the tire circumference direction T are formed at a predetermined interval in the tire width direction.

Left and right lug grooves 5 extending from the narrow groove 2 towards the both outer sides in the tire width direction are arranged at a predetermined pitch along the tire circumference direction T. A lot of blocks 6 are defined in the tread surface 1 by the narrow groove 2, the main grooves 3 and 4, and the lug grooves 5. These blocks 6 are divided into six block rows extending in the circumference direction of the tire by the narrow groove 2 and the left and right main grooves 3 and 4. In the center area 1A of the tread surface 1 between the left and right main grooves 4, two left and right block rows X1 and two left and right block rows X2 are formed. In each of left and right shoulder areas located outside the left and right main grooves 4, one block row X3 is formed.

Left and right main groove parts 3a and 4a divided by each of the left and right lug grooves 5 are formed as inclined grooves with directivity such that they expands towards the reverse direction to the tire rotating direction R. The scope of the inclination is within a scope of the so-called see-through state that when the tread surface 1 is developed for one round of

the tire in the circumference direction of the tire and the main grooves 3, 4 are viewed from the circumference direction of the tire, an unobstructed view can be obtained between one circumference end and the other circumference end of the main grooves 3 and 4. The main grooves 3 and 4 are see-through grooves formed by continuously connecting these inclined grooves with directivity.

The left and right lug grooves 5 are inclined grooves inclining from the narrow groove 2 towards the reverse direction to the rotating direction R of the tire. The inclined grooves are shaped in a circular arc which is convex towards the reverse direction to the rotating direction of the tire. The lug grooves 5 are placed in a way that left ones are shifted from right ones by predetermined length in the circumference direction T of the tire so that the left and right lugs are asymmetry to the center line CL of the tire. Each lug groove 5 has wider groove width at the side of the center line CL of the tire and narrower groove width at the side of the shoulder area 1B. The lug grooves 5 are tapered grooves in which the groove width decreases gradually from the center line CL of the tire towards outside in the width direction of the tire.

The average tire circumference direction length of the tire circumference direction length L of the blocks 6A of the block rows X1 and X2 in the center area 1A is within a range of 4 to 5 % (total pitch number of one round of the tire is substantially

20 to 25) of the tire full circumference length on the tire center line CL. The tire circumference direction length L of the blocks 6A in the center area 1A is longer than those of conventional tires. Thus, in the center area 1A, high stiffness of the blocks in the circumference direction of the tire can be obtained while securing a larger groove area by increasing the groove width of the lug groove 5 as mentioned above.

On the surface of each block 6B in the left and right shoulder areas 1B, a subgroove 7 crossing the block 6B in the width direction of the tire is formed, thereby dividing the block 6B into small front and back blocks 6B1. The subgrooves 7 extend to the blocks 6A of the block rows X2 in the center area 1A which are adjacent to the block rows X3 in the shoulder areas 1B. In the figure, inner ends 7a of the subgrooves 7 are located within the blocks 6A, but the subgrooves 7 may be connected to the main grooves 3, thereby dividing the blocks 6A in front and back.

As described above, in the present invention, since the average tire circumference direction length of the blocks 6A in the center area 1A is 4 to 5% of the tire full circumference length and the blocks 6A are longer than conventional tire blocks, the block stiffness in the center area 1A is increased. As a result, dry performance (handling performance and braking ability) can be improved.

Since the lug grooves 5 are inclined grooves inclining to

the reverse direction of the tire rotating direction R and the groove width thereof is wider in the center area 1A which affects drainage performance largely, wet performance can be improved in comparison with conventional tires having the same groove area.

As described above, since the average tire circumference direction length of the blocks 6A is longer and the groove area of the lug grooves 5 in the center area 1A is larger, noise is increased. However, since the left and right main groove parts 3a and 3b divided by the lug grooves 5 are formed as inclined grooves, air column resonance caused by the main grooves 3 and 4 is decreased and noise around 1 kHz can be improved.

Further, since the blocks 6B in the shoulder areas 1B are divided into the small blocks 6B1 by the subgrooves 7, pitch number defined by the subgrooves 7 and the lug grooves 5 in the shoulder areas 1B becomes substantially two times of that in the center area 1A. Thus pitch number is different in the shoulder areas 1B and the center area 1A, thereby contributing to conversion of pitch noise to white noise (dispersion of generated frequency).

Furthermore, since the groove width of the left and right lug grooves 5 is gradually narrower towards outside in the width direction of the tire, air pumping noise in the shoulder areas 1B caused by the lug grooves 5 can be reduced.

Therefore, noise increase caused by improvements in the

dry performance and the wet performance is offset, and noise performance can be maintained at a level equivalent to conventional tires.

Moreover, since the narrow groove 2 and the main grooves 3 and 4 formed on the tread surface 1 are arranged substantially straight along the circumference direction T of the tire as in the conventional tires, uneven wear resistance may not be degraded.

When the average tire circumference direction length of the blocks 6A is less than 4%, it is difficult to effectively improve the dry performance due to a decrease in the block stiffness. On the other hand, when it is over 5 %, noise performance is degraded.

When the lug grooves 5 are not the gradually narrowing grooves mentioned above and the groove width is constant, wet performance cannot be effectively improved and noise performance is deteriorated.

In the present invention, the foregoing groove width of the narrow grooves 2 may be 1 to 5 mm. When the groove width is narrower than 1 mm, drainage effect is degraded. On the other hand, when the groove width is wider than 5 mm, noise by air column resonance increases.

The left and right lug grooves 5 are preferably formed at variable pitches in the circumference direction T of the tire to convert the pitch noise to white noise. In this case, the

subgrooves 7 are preferably formed so that a number of different pitch lengths (pitch types) in each of the shoulder areas 1B is substantially two times of the number of pitch types in the center area 1A. Thus the conversion of the pitch noise to white noise becomes better.

The groove area ratio of the whole groove area to the tread surface area may be 26 % to 36 % as in the prior art.

The present invention may preferably be applied to a pneumatic tire particularly for passenger cars, but is not limited to them.

EXAMPLES

Tires 1 and 2 according to the present invention and comparative tires 1 to 4 which have a tread pattern shown in Fig. 1 and have the average tire circumference direction length in the center area and a lug groove structure shown in Table 1, and conventional tires which have a block pattern composed of main grooves extending straight in the tire circumference direction and lug grooves extending in the tire width direction were prepared. The size of all the tires is 225/45ZR17.

In the present invention tires 1, 2 and the comparative tires 1 to 4, the narrow groove width is 3 mm, and the groove area ratio is 33 %. In the conventional tire, the average circumference direction length of the blocks is 3.5 % of the tire full circumference length on the tire center line, and the groove

area ratio is 33%.

Each of these test tires was assembled to a rim having a rim size of 17×7 1/2 JJ and was mounted to a car having 2500 cc displacement with the tire air pressure being 220 kPa. And then the evaluation testing for dry performance, wet performance, noise performance and uneven wear resistance were performed under the following measurement conditions and the results shown in Table 1 were obtained.

Dry performance

Handling performance

A feeling test of handling performance by five test drivers was carried out on a dry test course, and the results were indicated by an index, where the index of the conventional tire was 100. A bigger index means better handling performance in a dry state.

Braking ability

Braking distances, when braked at a speed of 100 km/h on a dry test course, were measured, and the results were indicated by an index, where the index of the conventional tire was 100. A bigger index means better braking ability in a dry state.

Wet performance

Handling performance

A feeling test of handling performance by five test drivers was carried out on a wet test course, and the results were indicated by an index, where the index of the conventional tire

was 100. A bigger index means better handling performance in a wet state.

Braking ability

Braking distances, when braked at a speed of 100 km/h on a wet test course having a water depth of about 3 mm, were measured, and the results were indicated by an index, where the index of the conventional tire was 100. A bigger index means better braking ability in a wet state.

Drainage performance on straight running

When the test car ran straight into a wet road having an average water depth of 10 mm, a speed at which hydroplaning occurred was measured, and the results were indicated by an index, where the index of the conventional tire was 100. A bigger index means better drainage performance on straight running.

Drainage performance on turning

When the test car ran into a wet road having an average water depth of 10 mm after circling with a radius of 100 m at a constant speed, a speed at which hydroplaning occurred and the maximum acceleration at that time were measured, and the results were indicated by an index, where the index of the conventional tire was 100. A bigger index means better drainage performance on turning.

Noise performance

When the test car ran straight at a speed of 60 km/h on a

paved test course, pattern noise was measured, and the results were indicated by an index, where the index of the conventional tire was 100. A bigger index means better noise performance.

Uneven wear resistance

After the car ran 10,000 km at an average speed of 40 km/h on a paved test course, the difference between the maximum wear amount and minimum wear amount of each block of the test tires was measured, and the results were indicated by an index, where the index of the conventional tire was 100. A bigger index means better uneven wear resistance.

When the above index values are equal to or more than 105, the performance is effectively improved, and when they are 96 to 104, it belongs to the conventional level.

Table 1

	Conv.	Cmp. 1	Ex.1	Ex. 2	Cmp. 2	Cmp. 3	Cmp. 4
Av. Length %	3.5	3.5	4	5	5.5	4	5
Lug G	Const.	Taper.	Taper.	Taper.	Taper.	Const.	Const.
Dry Handling	100	103	105	108	110	102	105
Brake	100	103	106	109	110	103	106
Wet Handling	100	103	106	108	108	103	104
Brake	100	107	106	105	103	100	101
Drain. S	100	105	107	107	108	103	103
Drain. T	100	103	105	105	104	102	102
Noise	100	105	100	97	94	95	92
Uneven	100	103	105	107	110	102	105

Note:

Av. Length: Average tire circumference direction length of blocks
Lug G: Lug groove

Dry:	Dry performance
Handling:	Handling performance
Brake:	Braking ability
Wet:	Wet performance
Drain. S:	Drainage performance on straight running
Drain. T:	Drainage performance on turning
Noise:	Noise performance
Uneven:	Uneven wear resistance
Conv.:	Conventional tire
Ex.:	Present invention tire
Cmp.:	Comparative tire
Const.:	Constant width groove
Taper.:	tapered groove

As can be seen in Table 1, it is understood that the tires according to the present invention are capable of improving the wet performance and the dry performance, while maintaining the noise performance and the uneven wear resistance at a conventional level or higher.

As described above, the pneumatic tire of the present invention can improve the dry performance, since the average tire circumference direction length of the blocks in the center area of the tread surface is longer than those of conventional ones so that block stiffness can be higher in the center area.

Moreover, since the lug grooves are inclined grooves inclining to the reverse direction to the rotating direction of the tire and the width of the grooves are wider at the center area, the wet performance can be improved.

Furthermore, degraded noise performance caused by increase in the average tire circumference direction length of

the blocks and in the lug groove area in the center area of the tread surface can be compensated by making the left and right main groove parts inclined to reduce air column resonance, by placing the subgrooves in the shoulder areas to convert the pitch noise to white noise, and by making the lug grooves tapered to reduce air pumping noise in the shoulder areas. Accordingly, the noise performance can be maintained at an equivalent level to conventional ones.

Further, since the narrow groove and the main grooves formed on the tread surface have a structure such that they extend substantially straight in the circumference direction of the tire as in the prior art, the uneven wear resistance may not be degraded unlike a tire having V-shaped grooves.

CLAIMS

1. A pneumatic tire having a tread surface the tire rotating direction of which is specified to one direction, a narrow groove extending straight in a circumference direction of the tire on a tire center line of the tread surface, two main grooves extending in the tire circumference direction on each of left and right sides of the tread surface, left and right lug grooves being placed on the tread surface at a predetermined pitch in the tire circumference direction, the lug grooves inclining to the reverse direction of the tire rotating direction and extending from the narrow groove towards both outsides in the tire width direction, four block rows in a center area of the tread surface and one row in each of left and right shoulder areas being defined by the narrow groove, the main grooves and the lug grooves, the block rows extending in the tire circumference direction,

wherein the average tire circumference direction length of the blocks of the block rows in the center area is 4 to 5 % of the tire full circumference length on the tire center line;

each of the left and right lug grooves is formed as a tapered groove having wider width on the side of the tire center line and narrower width on the side of the shoulder area;

the left and right main grooves have main groove portions located between the lug grooves arranged at the predetermined pitch in the tire circumference direction, the main grooves portions being formed as inclined grooves inclining so as to

expand towards the reverse direction of the tire rotation direction, the main grooves being formed by continuously connecting the inclined grooves so that when the tread surface is developed for one round of the tire in the tire circumference direction and when the main grooves are viewed from the tire circumference direction, an unobstructed view can be obtained between one circumference end and the other circumference end of the main grooves; and

a subgroove is provided on a surface of each block in the left and right shoulder areas, the subgroove crossing the block in the tire width direction.

2. The pneumatic tire according to claim 1, wherein the main groove portions between each of the lug grooves are formed as inclined grooves inclining so as to expand towards the reverse direction of the tire rotating direction.

3. The pneumatic tire according to claim 1 or 2, wherein the groove width of the narrow groove is 1 mm to 5 mm.

4. The pneumatic tire according to claim 1, 2 or 3, wherein an inner end of the subgroove is located within the block in the center area adjacent to the block row in the shoulder area.

5. The pneumatic tire according to claim 1, 2 or 3, wherein the inner end of the subgroove is connected to an inner main groove of the main grooves.

6. The pneumatic tire according to claim 1, 2, 3, 4 or 5, wherein the left and right lug grooves are placed in a state of

shifting each other in the tire circumference direction.

7. The pneumatic tire according to claim 1, 2, 3, 4, 5 or 6, wherein the left and right lug grooves are placed at variable pitches in the tire circumference direction.

8. The pneumatic tire according to claim 7, wherein the subgrooves are arranged so that a number of pitch types defined by the subgrooves and the lug grooves in the shoulder areas is two times of the number of pitch types defined by the lug grooves in the center area.

INVESTOR IN PEOPLE

Application No:	GB 0212787.6	**Examiner:**	Roger Binding
Claims searched:	1-8	**Date of search:**	10 August 2002

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.T): B7C (CDJ)

Int Cl (Ed.7): B60C 11/03, 11/04, 11/06, 11/08, 11/11

Other: Online WPI EPODOC JAPIO

Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
A	EP 0648622 A (SUMITOMO), see Fig 2.	
A	JP 090226326 A (BRIDGESTONE), and WPI Abstract Accession No. 1997-485470 (45), see abstracts and Figs 1 and 2.	

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.